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INTER-COMPANY CORRESPONDENCE

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TO Mr. J. R. McGuffey, K-1029
LOCATION Mechanical and Structural Engineering

DATE January 25, 1954

ANSWERING LETTER DATE

ATTENTION

SUBJECT BELLOWS FAILURES IN K-29 SIX INCH G-17 VALVES

KLI-2808

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Introduction

The failed bellows from two 6 inch G-17 valves which failed in K-29 in the newly installed process gas piping have been examined. These valves were from a group of 30 units recently withdrawn from Stores for installation. History of these units was unavailable because some of the valves had had previous plant service and maintenance prior to their withdrawal from Stores.

Upon removal of the valves, appreciable amounts of mercury were found in the system. The mercury was reported to have entered the system during vacuum testing at an absolute pressure of about 2 microns. The failures of the bellows were detected during vacuum leak testing and reportedly occurred on three valves which had been cycled several times during the testing procedure. These valves were located at a low point in the piping system where the mercury tended to collect.

The bellows from the two valves were submitted for examination to determine if the failures were attributable to the presence of mercury in the valves.

Conclusions

The bellows, identified spectrographically as brass (81% copper, balance zinc), failed because of stress-corrosion cracking as evidenced by the intergranular path of the failures. The cracking propagated from the inner surface of an outer convolution on one of the failed bellows and from the inner surface of an inner convolution on the other bellows. The inner surfaces also showed dezincification.

The exposure of the bellows to mercury had only occurred on the outer surface of the valve bellows assembly. Therefore, it is concluded that the failures of these bellows were not caused by the presence of the mercury in the system but were the result of stress-corrosion attack from previous exposure of undetermined origin prior to installation.

The literature states and laboratory tests demonstrated that mercury and mercury compounds are capable of producing stress-corrosion cracking in brass; therefore, the presence of mercury in this system is undesirable.

Procedure, Results and Discussion

The failure locations were found by hydrostatically testing the bellows assemblies. The failures in both bellows occurred in the lower section of the assemblies (nearest the valve seat). Samples were taken from the failure areas in the sections and were examined metallographically. Both failed bellows revealed intergranular cracks originating from the inner surface of the bellows. The path of the cracks, as revealed in the first and second valve bellows examined, are shown in figures 1 and 2, respectively. Figure 1 shows cracks originating from the inner surface of an inner convolution while figure 2 reveals similar cracks originating from the inner surface of an outer convolution. Both surfaces of the bellows, but particularly the inside surface, showed a pitting type of attack with spongy deposits of copper which is indicative of a dezincification type of attack. The reported cycling of the valves during the leak testing probably induced stresses sufficiently great at regions of maximum motion to allow stress-corrosion cracks, that may have already existed or may have developed at dezincified locations in the bellows during cycling, to penetrate the bellows wall.

A test was conducted in which the outer surface of a brass bellow was exposed partially immersed to metallic mercury and to mercury vapor in an evacuated dessicator. The brass bellows was maintained in highly stressed condition during the test. This procedure produced failure of the bellows within a period of a few hours exposure. Although the bellows failures examined in this investigation were not due to the mercury found in the system it should be recognized that the presence of mercury is undesirable since mercury and mercury compounds readily induce stress-corrosion failure in stressed brass.

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Trouble Shooting
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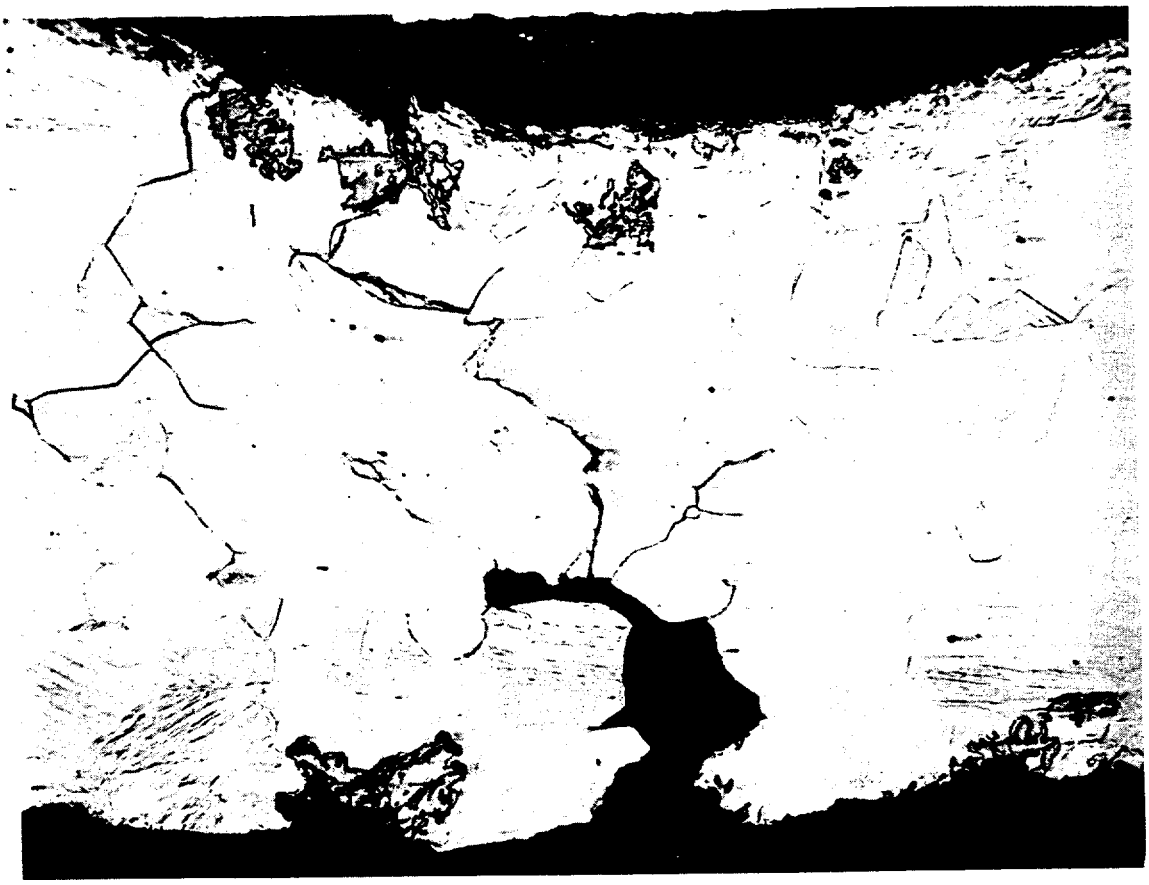

Figure 1

INTERGRANULAR PATH OF THE FAILURE

Plate 2177, Sample 5800, 500X, Chromic Etch

This photomicrograph illustrates stress-corrosion cracking which is evidenced by the intergranular path of the failure from the inner surface of an inner convolution. Also shown is the deposition of copper resulting from a dezincification attack of the brass. This sample was taken from the lower section of the first valve failure examined.

Figure 2

INTERGRANULAR PATH OF FAILURE

Plate 2203, Sample 5919, 500X, Chrome Etch

Stress-corrosion cracking originating from the inside surface of an outer convolution of the bellows. This bellows sample was taken from the second valve failure examined.